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Demonstration of a prototype hydrogen sensor and electronics package

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Disclaimer

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DEMONSTRATION OF A PROTOTYPE HYDROGEN SENSOR AND ELECTRONICS PACKAGE

Progress Report

SCAQMD Contract No. 16039
Reporting time period: May 27, 2016 to July 26, 2016

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Task	Completion by
1. Station Demonstration and Site Recommendation	3/26/16
2. Order Sensor Equipment	3/26/16
3. Build Sensors	5/26/16
4. Install Sensors	7/26/16
5. Sensor Demonstration and Data Analysis	1/26/17

Table 1. List of contract tasks and expected completion dates

✓ **Task 1: Hydrogen Frontier—Chino station selected for second site demonstration.**

✓ **Task 2: All necessary targets, substrates and electronics equipment was ordered.**

✓ **Task 3: Three sensor units were prepared.**

In an effort to improve sensor lifetime and robustness, LLNL is leveraging in-house deposition chambers and LLNL technology maturation (Tech Base) funds to prepare platinum (Pt), indium tin oxide (ITO) and yttria-stabilized zirconia (YSZ) depositions via pulsed power magnetron sputtering. A graded approach to Pt depositions has resulted in good adhesion, qualified via tape testing (ASTM D3359), with an electrode thickness of ~1 μm (as compared with the 10 μm thick, commercially screen printed Pt used in current sensors). This reduction in electrode step height allows subsequent depositions of ITO and YSZ to be made thinner, thus reducing deposition time/expense. We anticipate that thinner depositions can improve sensor robustness by reducing the build up of residual thermal stresses.

While this development is outside the scope of this study, thinner deposition sensors can provide a useful performance comparison with current chromite sensors and may provide improved lifetime durability and performance.

✓ **Task 4: Sensor and weather station installed at Chino.**

The hydrogen safety sensor was installed in the compressor room (Fig. 1) at the Hydrogen Frontiers station in Chino, CA on 7/28/16. The compressor is known to leak during dispenser activity, making this a strategic position to detect leakage in the relative absence of environmental factors (i.e., wind).

Fig. 1. Sensor installation images from H2F Chino showing (a) computer for data acquisition placed in the filling station control room, (b) Dan Poppe installing sensor unit and (c) Chris Romero wiring 24VDC to the sensor power supply in the compressor room.

Task 5: Data logging at Burbank was initiated on April 27th. Data logging at Chino initiated July 28th.

LabView source code developed under the DOE-funded H2 Safety Sensor field trials work was obtained from the original LabView developer and sent to LLNL to investigate the possibility of making improvements to the control software. Software upgrades are underway and cost for modifications is now covered through LLNL Tech Base funds.

As a control, the sensor electrodes of the unit located in the compressor room at Burbank were grounded so that the effect of environmental conditions on the sensor electronics could be evaluated. Burbank sensors placed in different locations (compressor room and dispenser) showed similar baseline behavior—note the nearly identical trends between day and night data in Fig. 2). This indicates that the baseline drift is a result of temperature affecting electronic circuits and could be corrected through an improved circuit design.

The sensor unit in the Burbank compressor room was put into normal service on July 28th using the same chromite-based sensor. The sensor in the H2F Chino dispenser unit was upgraded to an ITO device and the chromite sensor that was tested from April 27th to July 28th was recovered and will be tested at LANL to see if there was any measureable change in sensor performance after 92 days of operation. Cyclic baseline behavior occurs in approximately 24-hour intervals and is attributed to thermal drift in the electronics as a function of temperature. This is supported by data from the compressor room field trials unit collected in Task 5. No measureable drift in the sensor baseline voltage (constant 0.05 V, Fig. 3) was seen during the first 92 days of field trials testing despite unseasonably high temperatures and recorded wildfires known to be present

in the greater Los Angeles area. Additionally, both CSS power supplies were operating despite the high temperature inside the equipment enclosures and surrounding areas of the equipment skids.

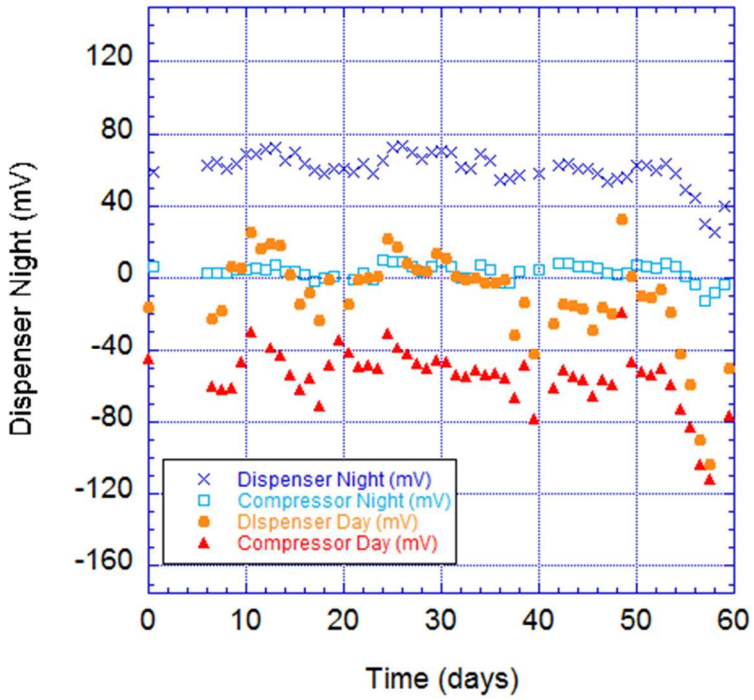

Fig. 2. Sensor baseline behavior at the Hydrogen Frontiers Burbank station over 60 days from April to July in 2016 with baseline voltage measured at 0 slope, twice (night and day) during each 24 hour cycle.

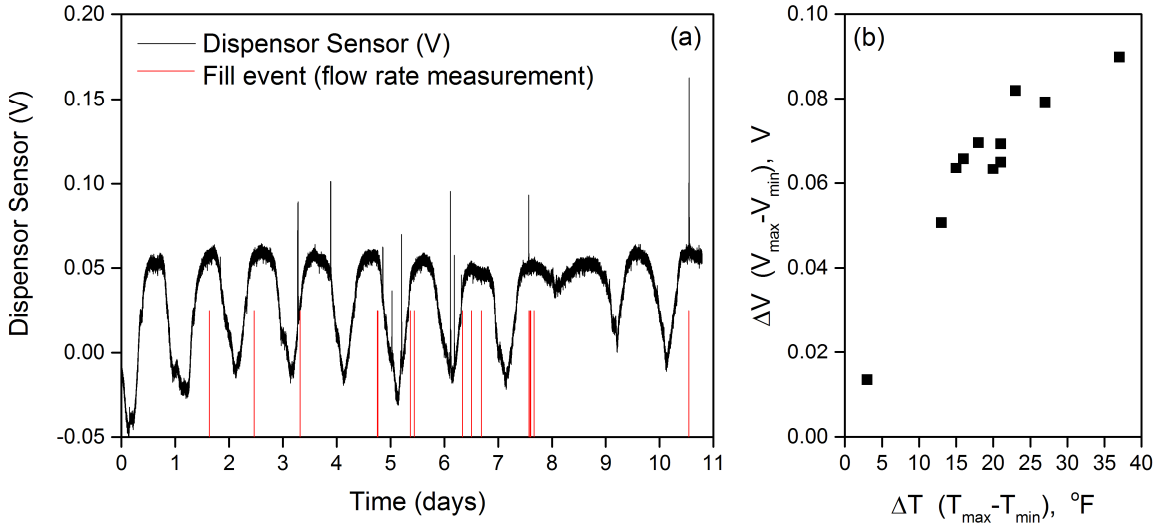

Fig. 3. Effect of temperature on sensor electronics evidenced by a periodic (24 hour) baseline shift in (a) dispenser sensor voltage measurement, supported by (b) baseline shift vs. daily temperature variation.

Schedule

All work is proceeding according to the planned schedule.

	3/26/16	5/26/16	7/26/16	1/26/16
Task 1	▯			
Task 2	▯			
Task 3		▯		
Task 4			▯	
Task 5				X

Table 3. Planned (black) and executed (blue) work

Budget

- $100,000 subcontract allotment to LANL for sensor materials, deposition and construction, station selection, installation support and monitoring
    - $24,339.50 was incurred during this time period for researcher time, materials and travel to LA for sensor maintenance/installation.
    - Total remaining balance for project support is $66,448.70.
- $75,000 allotment to LLNL for station selection, sensor monitoring, project management and reporting
    - $934.56 was incurred for travel to LA for sensor maintenance and $16,260.74 was incurred for researcher time.
    - Total remaining balance is $57,804.70.

Current LLNL and LANL funds are sufficient to support sensor monitoring, reporting and publication efforts.

Planned Work for July 27, 2016 to January 26, 2016

- Complete LabView software upgrades to allow for independent baseline calibration of multiple sensors at a single location (LLNL).
- Deposit indium tin oxide and yttria-stabilized zirconia and evaluate microstructure, thermal stability and robustness (LLNL; effort funded through LLNL Tech Base).
- Complete NREL validation and verification of lanthanum chromite electrode sensors and environmental testing of electronics (LANL).
- Monitor field trial units at Burbank and Chino (LLNL and LANL).
- Summarize and report on sensor performance (LLNL).

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